BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 12095

SUBJECT: Feasibility of Shuttle (Orbiter)/S-IC Launches at LC-39 - Case 320

DATE: December 31, 1969

FROM: C. H. Eley, III

ABSTRACT

The concept of launching a Space Shuttle second stage (Orbiter) with a Saturn V S-IC stage from LC-39 appears feasible so long as the length and configuration of the Orbiter are compatible with the LUT. In this way, there will be a minimal impact on launch complex hardware from a modification and cost standpoint.

Assuming an autonomous checkout capability for the Orbiter, the pad test and countdown requirements would be considerably less than for the Apollo/Saturn V. This would permit a relatively high launch rate depending on the number of LUT's used. Assuming a range of 15 to 30 days LUT refurbishment time after each launch, the launch rate achievable increases markedly as the on-pad time decreases.

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MEMORANDUM FOR FILE

A recent memorandum (Reference 1) discussed series development of the Orbiter and booster stages of the space shuttle. In this concept, the reusable Orbiter (second stage) is developed ahead of the reusable booster (first stage) by flying the Orbiter with a Saturn V first stage (S-IC). Recognizing that the shuttle configuration is quite fluid at present, there are several proposed configurations which could be flown atop an S-IC stage without extensive modifications to LC-39 launch hardware. The purpose of this memorandum is to briefly present the feasibility of launching an Orbiter/S-IC configuration from LC-39.

1. ORBITER/S-IC CONFIGURATION

The shape of the Orbiter is the main area of concern in an Orbiter/S-IC vehicle for a launch from LC-39. For instance, impact on launch hardware depends on the Orbiter/S-IC overall length being the same as that of the Apollo/Saturn V. For purposes of this discussion, several broad assumptions are made:

a. The S-IC length will not change (=140 ft).

b. The interface-adapter between the Orbiter and the S-IC is approximately 10 ft. in length.

c. The length of the orbiter is 183 ft.

A general comparison between an Orbiter/S-IC, the Apollo/Saturn V, and the Launch Umbilical Tower (LUT) is shown in Figure 1. A concept of the Orbiter/S-IC mated to the LUT is presented in Figure 2. The importance of the length of the Orbiter/S-IC can be readily seen in Figure 2 since the LUT swing arms do not have to be moved. LUT swing arms #1, #2, #4, #8, and #9 would remain. Swing arms #3, #5, #6, and #7 would be removed or permanently swung aside since they would not be required. Removal is the better choice to preclude blast damage from the F-1 engines after liftoff.

2. S-IC SERVICING

All servicing interfaces (swing arm, umbilicals, etc.) remain identical to that for a normal Apollo/Saturn V launch, including the holddown arms and tail service masts. Servicing during pad operations would be identical to that performed during Apollo/Saturn V operations.

3. ORBITER SERVICING

As indicated in Figure 2, all orbiter servicing (propellants, gases, etc.) would be provided across swing arm #4. This includes loading or unloading LOX and LH_2 as well as electrical and pneumatic connections. Swing arm #8 would be used to provide air-conditioning, venting, instrument cooling, and electrical or pneumatic services for the Orbiter payload. Flight crew and/or passenger loading could be accomplished across swing arm #9 through the white room in the same manner as for the Apollo/Saturn V. Retraction of all swing arms during launch operations would remain the same as in a normal Apollo/Saturn V launch (indicated in Figure 2).

4. PAYLOAD

For the Orbiter/S-IC vehicle, it is assumed that the payload will be integrated with the vehicle in the VAB. If external access to the payload is required at the pad, a special platform arm may have to be added to the LUT. This would not be a particularly expensive modification, but might become necessary since the MSS would not be used at the pad.*

5. TEST FLOW

The test flow at KSC is considered in two phases.

a. Pre-Rollout - This portion of the overall test flow encompases receiving, inspection/repair, and pre-mate checkout of both the S-IC and Orbiter stages. Checkout of the S-IC would closely follow current procedures. Checkout can only be surmised for the Orbiter since it might include some refurbishment after its previous mission. A great deal of autonomous checkout is assumed.

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*Conceivably, the MSS would not be required to support Orbiter/S-IC pad operations.

After the individual stages are checked out, they are transferred to the LUT (in the VAB) and mated in preparation for move to the pad.

b. On-Pad - After the Orbiter/S-IC has been stacked on the LUT, the Crawler-Transporter (CT) transports the entire assembly to the pad. The time spent at the pad depends on (1) LUT/pad mating and interface verification requirements, (2) on-pad test requirements, and (3) launch (countdown) requirements. Assuming an autonomous checkout capability for the Orbiter, the pad test and countdown requirements would be considerably less than that for an Apollo/Saturn V. Based on present LUT/pad mating and interface verification requirements, the minimum on-pad time for an Orbiter/S-IC would be $\geq$ 5 days.

6. LAUNCH RATE

The launch rate at LC-39 for an Orbiter/S-IC would be governed by the same things that affect the launch rate for the Apollo/Saturn V (this refers to the "ideal" or maximum rate possible). The Orbiter/S-IC launch rate can therefore be given as:

$$L_r = \frac{365\ P_n}{T_p + R_1}$$

Where: L_r is the ideal launch rate (vehicles/year), P_n=the no. of LUT's,

T_p = the on-pad time from rollout to launch (days), and

R_1 = the LUT refurbishment time (days).

Some interesting results of this are shown in Figure 3.*

1. The launch rates possible are generally higher than expected.

2. Assuming a range of 15 to 30 days LUT refurbishment time after each launch, the launch rate increases rapidly as the on-pad time decreases.

*It is emphasized that to achieve the maximum launch rate, a seven-day work week is assumed. The launch rates achievable would be reduced 14% using a six-day work week and 28% using a five-day work week.

7. LAUNCH COSTS

Figure 4 is presented to give some idea of the effect of test flow requirements on KSC costs vs the launch rate. The figure is based on actual Apollo/Saturn V data, and shows that the cost curve begins tapering off at higher launch rates. Considering "ideal" launch rates, the estimated Orbiter/S-IC launch costs are shown in Figure 5 as a function of the launch rate and on-pad time.* LUT requirements are also indicated. One conclusion to be drawn from Figure 5 is that for a fixed budget, the program would get more for its money (in terms of more launches) with shorter on-pad requirements.

8. SUMMARY AND CONCLUSIONS

Recognizing that the space Shuttle configuration is quite fluid at present, there are several proposed Orbiter configurations which could be flown atop a Saturn V S-IC stage should series development of the Orbiter and booster stages of the Shuttle be adopted. After brief examination of the Orbiter/S-IC concept, it is concluded that:

1. Launching an Orbiter stage with a Saturn V S-IC stage appears feasible so long as the length and configuration of the Orbiter are compatible with the LUT.

2. Assuming an autonomous checkout capability for the Orbiter, the pad test and countdown requirements would be considerably less than that for the Apollo/Saturn V.

3. Assuming a range of 15 to 30 days LUT refurbishment time after each launch, the achievable launch rate increases rapidly as the on-pad time decreases.

4. The use of more than one LUT would significantly increase the maximum possible launch rate.

C. H. Eley, III

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Attachs.

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*The "launch costs" referred to here include only launch crew, operation of the launch complex, propellant costs, crew costs, and vehicle maintenance and repair.

REFERENCES

1. "Space Shuttle Development with Built-In Contingency" Case - 105-3 Bellcomm Memorandum for File Dated September 30, 1969 by D. E. Cassidy.

2. Handbook of Astronautical Engineering.

3. "On the Economy of Recoverable Two-Stage Orbital Carrier Vehicles" ARS Paper 1011-59, November, 1959 by H. H. Koelle and H. Thomae.

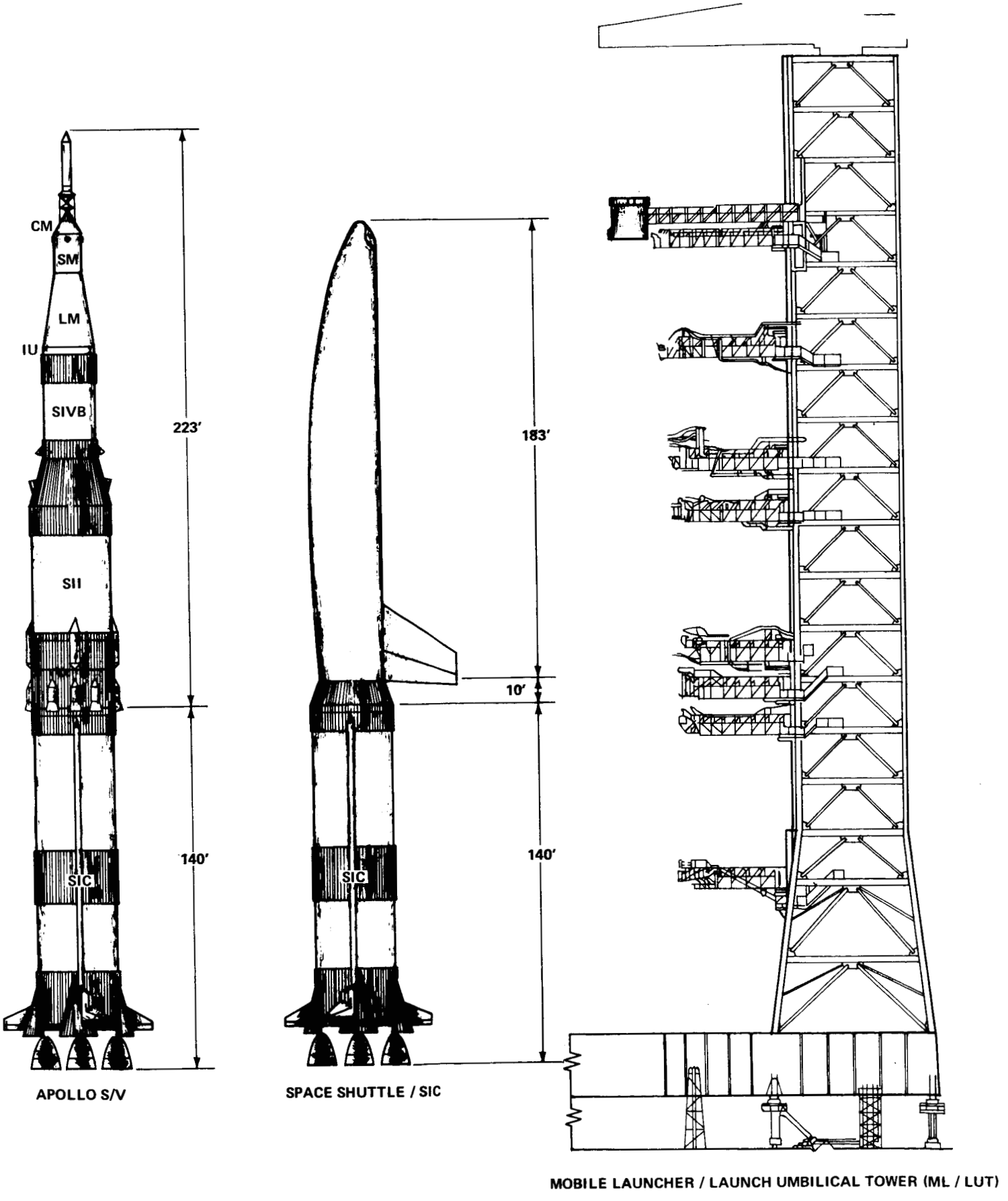
CM
SM
LM
IU
SIVB
SII
SIC
223'
140'
183'
10'
140'
SIC
APOLLO S/V
SPACE SHUTTLE / SIC
MOBILE LAUNCHER / LAUNCH UMBILICAL TOWER (ML / LUT)

FIGURE 1

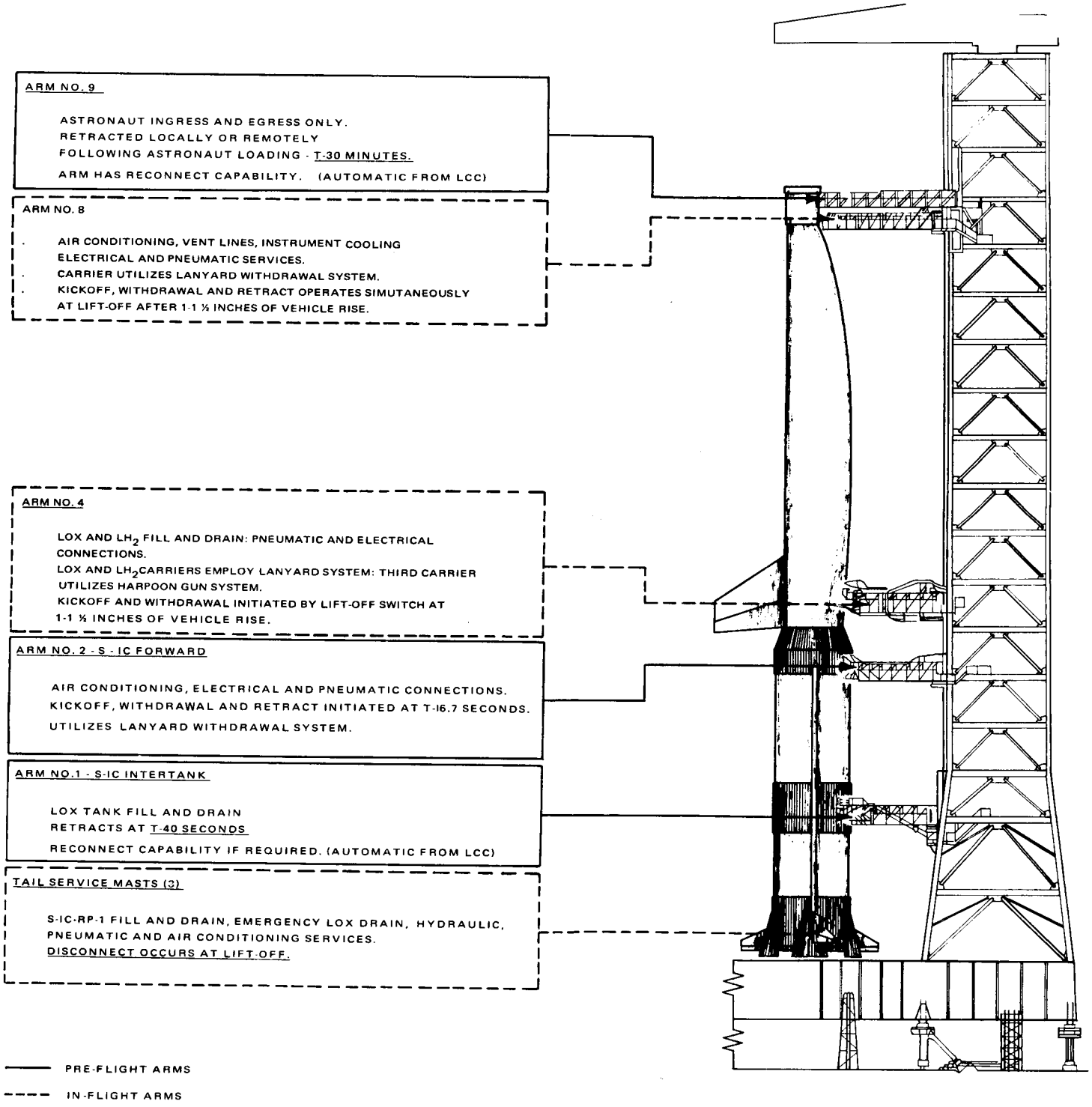

FIGURE 2 - ORBITER/SIC LAUNCH CONFIGURATION

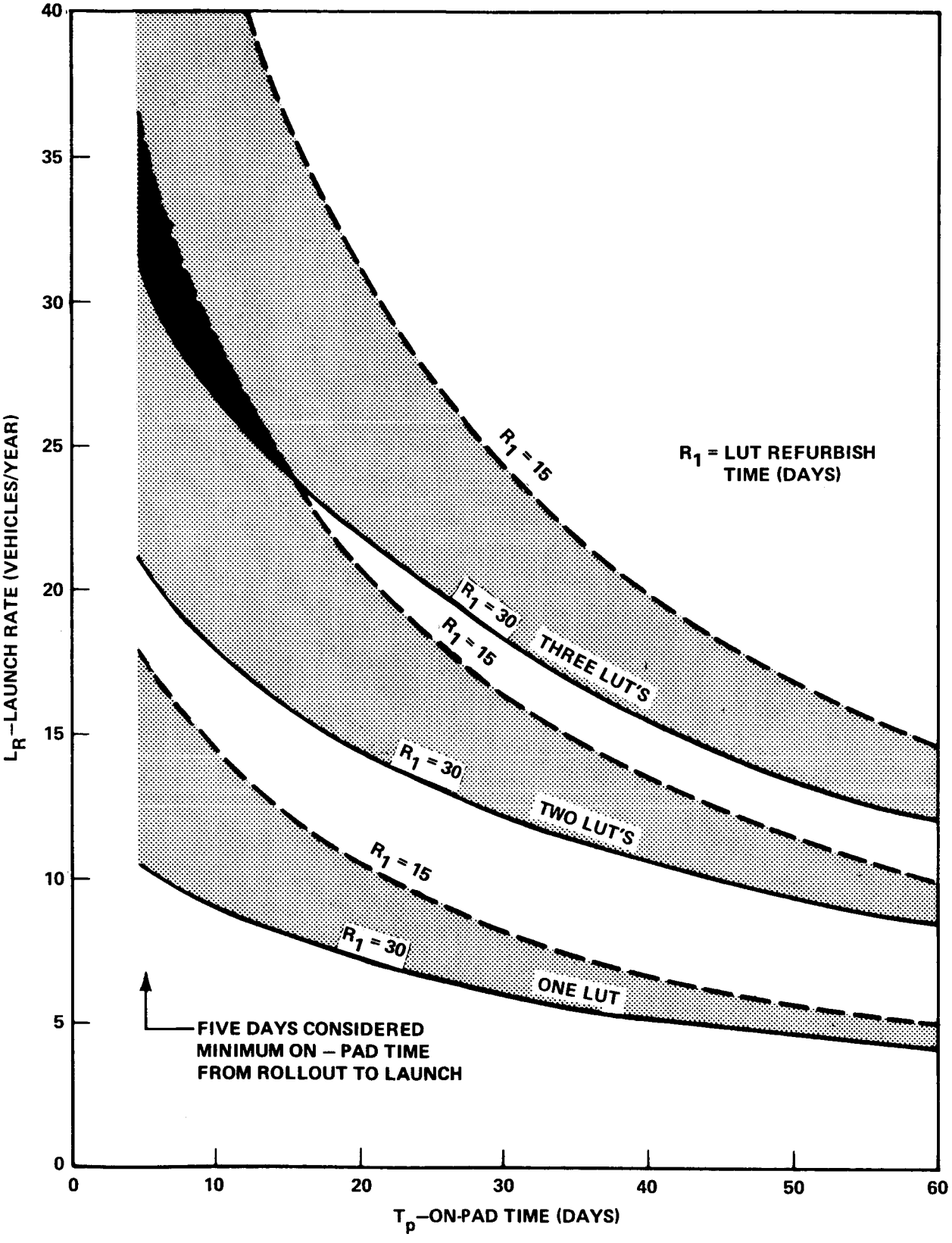

FIGURE 3 - ORBITER/SIC LAUNCH RATE AS A FUNCTION OF LUT'S USED AND PAD TEST FLOW REQUIREMENTS.

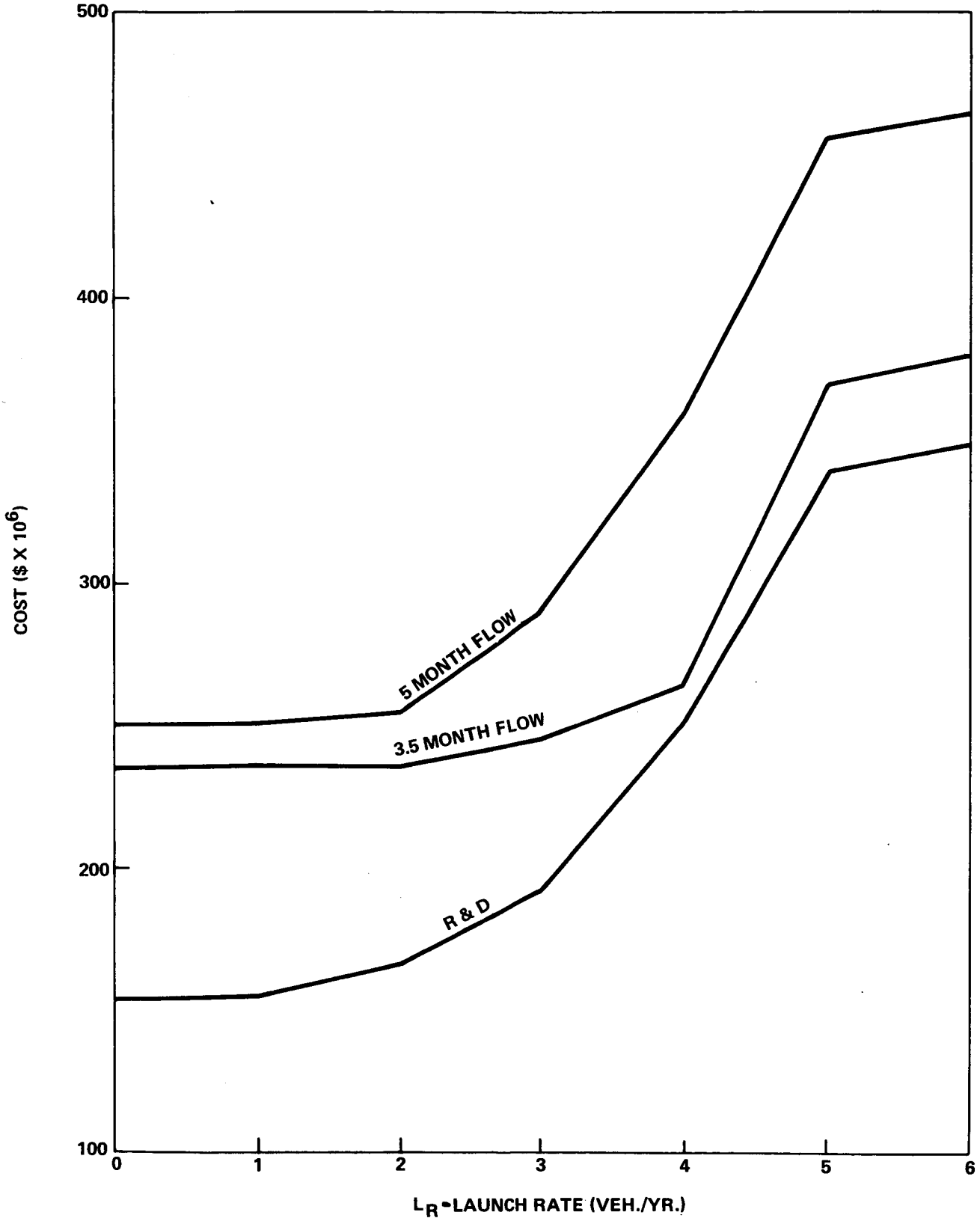

FIGURE 4 - APOLLO/SATURN V COSTS AS A FUNCTION OF LAUNCH RATE

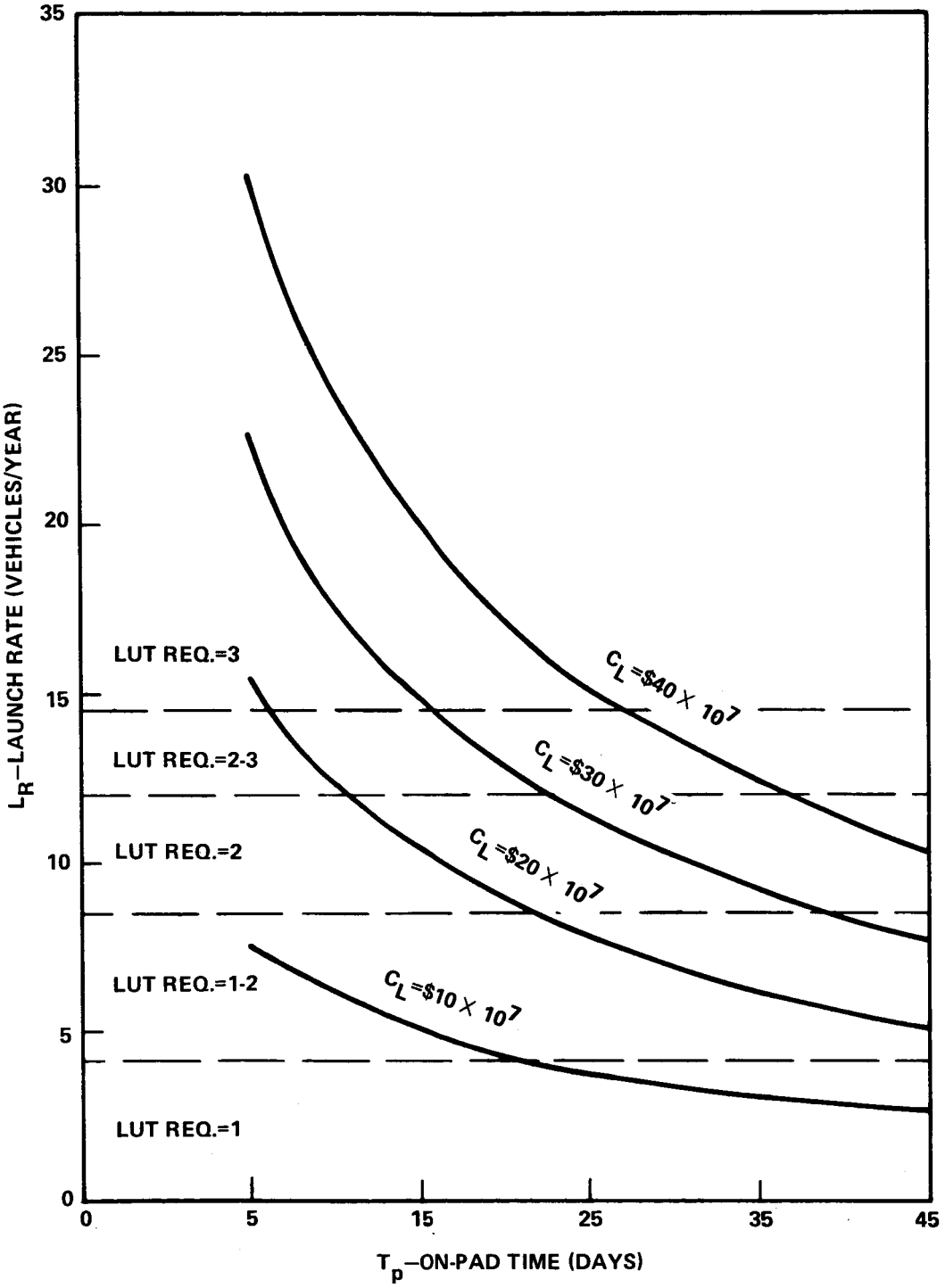

FIGURE 5 - ORBITER/SIC LAUNCH RATE AS A FUNCTION OF ON-PAD TIME FOR VARIOUS FIXED ANNUAL LAUNCH COST (C_L)